PIEZOELECTRIC THIN F[illegible] RESONATOR

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Abstract

PROBLEM TO BE SOLVED: To provide a piezoelectric thin film resonator with a wide band width and a wide oscillating frequency range when it is applied to a resonator, a filter or the like and having a large electromechanical coupling coefficient.
SOLUTION: This resonator is provided with a single crystal substrate 3, a piezoelectric thin film 2 formed on the single crystal substrate 3 and two electrodes 1 made of a conductive film formed on the piezoelectric thin film 2. In this case, the piezoelectric thin film 2 is made of e.g. lead zirconate titanate (PZT) or lead titanate (PT) thin film whose the thickness is 0.1-10 &mu m formed by a sol-gel method, an electric field is applied between the two electrodes 1 to apply polarization processing and to make the piezoelectric thin film. As required, an interval between the two electrodes 1 is made to 0.5-10 &mu m and a part of a rear side of the single crystal substrate is removed by etching.

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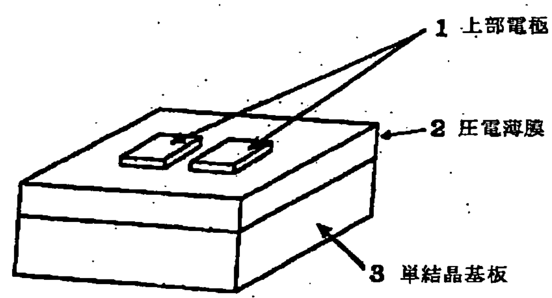
(54)【発明の名称】 圧電薄膜共振子

(57)【要約】

【課題】 電気機械結合係数が大きく、共振子、フィルタ等に適用した場合の帯域幅及び発振周波数範囲が広い圧電薄膜共振子を提供する。

【解決手段】 単結晶基板と、該単結晶基板上に形成された圧電体薄膜と、該圧電体薄膜上に形成された導電性膜よりなる２つの電極を備えた圧電薄膜共振子において、上記圧電体薄膜は、例えばゾルゲル法により形成された厚さ０．１～１０μmのチタン酸ジルコン酸鉛（ＰＺＴ）またはチタン酸鉛（ＰＴ）薄膜よりなり、上記２つの電極間に電界をかけ、分極処理し圧電体薄膜とした圧電薄膜共振子。必要に応じて、上記２つの電極の間隔は０．５～１０μmであり、単結晶基板の裏面の一部をエッチング除去したものである。



【特許請求の範囲】

【請求項1】単結晶基板と、該単結晶基板上に形成された圧電体薄膜と、該圧電体薄膜上に形成された導電性膜よりなる2つの電極を備えた圧電薄膜共振子において、上記圧電体薄膜はゾルゲル法により形成されたチタン酸ジルコン酸鉛（ＰＺＴ）またはチタン酸鉛（ＰＴ）薄膜よりなり、上記2つの電極間に電界をかけ、チタン酸ジルコン酸鉛（ＰＺＴ）またはチタン酸鉛（ＰＴ）薄膜を分極処理することにより圧電体薄膜としたことを特徴とする圧電薄膜共振子。

【請求項2】上記チタン酸ジルコン酸鉛（ＰＺＴ）またはチタン酸鉛（ＰＴ）薄膜が、ゾルゲル法で形成された厚さ０．１～１０μｍの薄膜であることを特徴とする請求項１記載の圧電薄膜共振子。

【請求項3】上記2つの電極の間隔が、０．５～１０μｍの構造であることを特徴とする請求項１～２のいずれかに記載の圧電薄膜共振子。

【請求項4】上記単結晶基板の裏面の一部をエッチングにより除去したことを特徴とする請求項１～３のいずれかに記載の圧電薄膜共振子。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、高周波域で動作する圧電体薄膜の横方向のバルク波を利用した共振器、フィルター等に好適な圧電薄膜共振子に関するものである。

【０００２】

【従来の技術】一般に、高周波帯域において使用される圧電振動子では、薄板の厚み振動が利用されている。従来、提供されている高周波用の圧電振動子としては、次の①～③の構成のものなどがある。

【０００３】①　水晶、圧電セラミックス等の圧電板を薄く研磨し、その基本振動を用いた圧電振動子。

②　水晶、圧電セラミックス等の高次振動を利用した高次モード振動子。

③　圧電性蒸着膜を基板上に形成し、この圧電性蒸着膜を励振して基板を高次振動させて用いる複合振動子。

【０００４】上記従来の圧電振動子のうち、①の構成のものでは、水晶、圧電セラミックス等の圧電板を薄くすれば、板厚に反比例して基本共振周波数が高くなるが、板厚を薄くすればするほど、機械加工が困難となる。このため、現在では、板厚３０～４０μｍで共振周波数５０ＭＨｚ程度が限界である。

【０００５】②の構成のものでは、高次振動を用いるため電気機械結合係数が小さくなり、周波数帯域幅が小さすぎて実用的ではなく、また、電気機械結合係数が大きい低次振動ではスプリアスとなる欠点がある。また、③の構成のものでも同様の欠点がある。

【０００６】ところで、圧電素子用の高周波用圧電材料としては、例えば、常誘電体のＡｌＮ、ＣｄＳ、ＺｎＯ等が用いられている。これらの材料は、機械加工により薄く加工したとしても、４０μｍ程度の厚みが限界であり、この程度の厚みのものでは、基本波の共振周波数は、いずれの材料でも数十ＭＨｚが限界である。これらの材料を用いた高周波用圧電薄膜共振子においては、例えば、５００ＭＨｚ以上の高い共振周波数の基本振動を得るためには、板厚を１０μｍ以下にする必要がある。

【０００７】一方、数百ＭＨｚの高周波帯域において、電気機械結合係数の大きな圧電振動子を得る方法としては、スパッタ法等の薄膜製造技術とエッチング技術を用いる方法があり、例えば、特開昭６０－３１３０５号公報には、スパッタ法で酸化亜鉛及びチタン酸鉛の薄膜を形成した圧電素子が記載されている。この特開昭６０－３１３０５号公報に記載される圧電素子は、基板の影響をなくし、圧電体薄膜の振動特性を活かすために、基板の一部をエッチングで除去している。

【０００８】なお、従来、厚み振動を用いた圧電薄膜共振子では、特開平８－１４８９６８号公報に記載される圧電薄膜共振子に代表されるように、圧電体膜の上下の電極により厚み方向のバルク波を励起させていた。しかし、従来のように厚み方向のバルク波を利用している圧電薄膜振動子の場合、下部電極が不活性領域であるために、それが妨げになって共振子の重要な要素であるＱ値が小さくなってしまう。

【０００９】

【発明が解決しようとする課題】以上の様に、従来の圧電材料は、いずれも電気機械結合係数が２０～３０％程度と小さいため、共振子、フィルタ等を構成した場合、帯域幅及び発振周波数範囲が限定される。なお、特開昭６０－３１３０５号公報では、この点を改善するために、基板の一部を除去しているが、このように基板を除去した場合、素子強度が低下するという欠点がある。

【００１０】従来、ＰＺＴのような電気機械結合係数の大きい圧電薄膜材料を構成するには、成膜プロセスに問題があり、良質な膜質の圧電体薄膜を得ることは困難と言う問題があった。また、ＰＴのような誘電率が小さく、キューリー点が約５００度と高く、厚み方向の結合係数と広がり方向の結合係数の値が大きく異なる等の特徴を持つ圧電薄膜材料を構成するには成膜プロセスに問題があり、良質な膜質の圧電体薄膜を得ることは困難と言う問題があっつた。そして下部電極を端子電極として露出させるために、圧電体膜をエッチングしたり、下部電極の一部を残して圧電体膜を上に形成したりするなど、下部電極を露出させるために工程が複雑になることがある。また、音響的に不活性領域であるためにそれが妨げになっつて、Ｑ値が小さくなってしまう。

【００１１】本発明は上記従来の問題点を解決し、電気機械結合係数が大きく、共振子、フィルタ等に適用した場合の帯域幅及び発振周波数範囲が広い圧電薄膜共振子であって、下部電極が必要なく、高いＱ値が得られ、従

って製造が容易な所望の圧電薄膜共振子を提供することを目的とする。

【0012】

【課題を解決するための手段】本発明の圧電薄膜共振子は、単結晶基板と、該単結晶基板上の圧電体膜と、該圧電体薄膜上に形成された導電膜よりなる２個の電極とを備えた圧電薄膜共振子において、上記圧電体膜がゾルゲル法により形成した厚み０．１～１０μｍのチタン酸ジルコン酸鉛（ＰＺＴ）またはチタン酸鉛（ＰＴ）（以下、単にＰＺＴまたはＰＴと言う）薄膜を有し、上記薄膜上に簡単な２つの上部電極を有し、該２つの上部電極に電界を印加して分極処理することにより圧電体薄膜とするものである。従って、下部電極が存在しないため分極処理は横方向に分極されることになる。また、音響的に不活性領域が存在しないために高いＱ値が得られる。

【００１３】本発明の圧電薄膜共振子は、圧電体膜が電気機械結合係数の大きい圧電材料であるＰＺＴまたはＰＴで形成されているため、高周波領域で広帯域なフィルタや発振周波数範囲の広い共振器を実現できる。

【００１４】しかも、上部電極が間隔をあけて２個形成されているため、この上部電極間に電界を印加することにより圧電体膜を、下部電極がないため、横方向に分極できる。

【００１５】ところで、特にＰＺＴまたはＰＴは、通常良質な膜質の圧電体薄膜を得ることが困難である。例えば、スパッタ法では、振動の共振を十分確認できるほど良好なＰＺＴまたはＰＴ薄膜を形成できない。

【００１６】これに対して、ゾルゲル法によるＰＺＴまたはＰＴ薄膜の成膜であれば、厚み振動に対して高い共振を示し、圧電体薄膜として有効に機能する良好な膜質のＰＺＴまたはＰＴ薄膜を形成することができる。このＰＺＴまたはＰＴ薄膜の膜厚は０．１～１０μｍであることが好ましい。

【００１７】また、分極処理効果の面から、上部電極同士の間の間隔（以下、「上部電極間隔」と称す。）は、０．１～１０μｍであることが好ましく、更に好ましくは０．５～５μｍである。

【００１８】本発明におては、単結晶基板の一部エッチングで除去して凹部を形成しても良く、これにより、発信周波数、挿入損失の特性を向上させることができる。

【００１９】本発明によれば、ＰＺＴまたはＰＴ薄膜の膜厚は０．１～１０μｍであり、上部電極間隔０．５～１０μｍで、共振周波数帯域２００ＭＨｚ～１０ＧＨｚの高特性圧電薄膜共振子が提供される。

【００２０】

【発明の実施の形態】以下に、図面を参照して本発明の実施の形態を説明する。

【００２１】図１は本発明の実施の形態を示す斜視図、図２は本発明の他の実施の形態を示す正面図、図３は本発明の別の実施の形態を示す斜視図、図４は本発明の異なる実施の形態を示す図であって、図４（ａ）は正面図、図４（ｂ）は側面図である。

【００２２】図１～４において、同一機能を奏する部材には同一符号を付してある。

【００２３】本発明の圧電薄膜共振子で用いる基板は、例えば、サファイア、ＭｇＯ、$SrTiO_3$などの単結晶基板を用いることが出来る。単結晶基板１であれば、表面が平滑であり、かつ機械的強度も十分であることにより、ゾルゲル法により、比較的簡単に、良好な膜質のＰＺＴまたはＰＴ薄膜を形成することができる。また、２つの電極を構成する導電膜としては、Ａｌ、Ｐｔ、Ａｕ等を主成分とする膜を用いることが出来る。

【００２４】本発明の圧電薄膜共振子は、上記の様な単結晶基板上に、ＰＺＴまたはＰＴ薄膜および上部電極層を順次成膜して得られる。圧電体薄膜としてのＰＺＴまたはＰＴ薄膜は、例えば、ゾルゲル法により成膜した厚さ０．１～１０μｍの薄膜であり、２つの電極を構成する導電膜としては、上記金属または合金膜を、例えばスパッタ法等で形成することが出来、その厚さは、通常の場合１０００～２０００Å程度であり、この２つの電極に電界をかけて分極処理することにより圧電性を付与する。

【００２５】本発明において、圧電体薄膜としてのＰＺＴまたはＰＴ薄膜３は、高周波対応とするために膜厚１０μｍ以下であることが必要とされ、好ましくは０．１～１０μｍ、より好ましくは０．２～３μｍの範囲で使用目的に応じて適宜決定される。なお、ＰＺＴまたはＰＴ薄膜の膜厚が薄過ぎると圧電効果が十分得られず、逆に、厚過ぎると良好な膜質が得られない。

【００２６】ＰＺＴまたはＰＴ薄膜３上の上部電極４（４Ａ，４Ｂ）としては、前述の導電性金属層をスパッタ法等によりパターニング形成することが出来る。

【００２７】本発明においては、図２に示す如く、単結晶基板１の裏面をエッチング処理して凹部５を形成した方が良い、このように凹部５を形成することにより、圧電薄膜共振子の機械的強度は若干劣るものの低次モードをより強く励振することが可能となり、発信周波数、挿入損失の特性を向上させることができる。

【００２８】この凹部５は、上部電極４Ａ，４Ｂの形成位置に対向する位置（上部電極を基板上に厚さ方向に透影した位置）に単結晶基板１の厚さの５０～１００％の深さで形成するのが好ましい。この際基板を圧電体膜の数倍程度にする。

【００２９】また、本発明においては、図３に示す如く、ＰＺＴまたはＰＴ薄膜３上に絶縁膜４を部分的に形成し、上部電極４Ａ，４Ｂを、この絶縁膜４とＰＺＴまたはＰＴ膜３の表出面とにまたがるように形成することにより、端子電極としての上部電極４Ａ，４Ｂの形成位置をずらして構造上の補強を図ることができる。この場合、この絶縁膜４の厚さは０．０５～１μｍ程度である

ことが好ましい。

【００３０】本発明の圧電体薄膜であるＰＺＴまたはＰＴ薄膜は、例えば、次に様にして形成される。単結晶基板上に、酢酸鉛等のカルボン酸鉛、ジイソプロポキシ鉛などの鉛アルコキシド等の鉛化合物；テトラエトキシジルコウム、テトライソプロポキシジルコニウム、テトラブトキシジルコニウム、ジメトキシジイソプロポキシジルコニウム等のジルコニウムアルコキシド等のジルコシチタン、ジメトキシジイソプロポキシチタン等のチタンアルコキシド等のチタン化合物を、２－メトキシエタノール等の溶剤に、所定のモル比で、かつ、金属酸化物換算の合計濃度が１０～２０重量％程度となるように溶解して得られたＰＺＴまたはＰＴ薄膜形成用組成物を、単結晶基板上にスピンコータ等により塗布して４００～６００℃で乾燥する。この塗布、乾燥を所望の膜厚のＰＺＴまたはＰＴ薄膜が得られるまで繰り返し、最後に６００～７００℃で１分～１時間焼成してＰＺＴまたはＰＴ薄膜を得る。

【００３１】ＰＺＴまたはＰＴ薄膜の分極処理は、このＰＺＴまたはＰＴ薄膜上に形成した２つの電極に２０～５０ＶのＤＣ電圧を１～６０分間印加することにより行うことができる。ここで、十分な分極処理をすることで圧電体薄膜として機能するようになるが、上記のＰＺＴまたはＰＴ薄膜の膜質が不十分だと分極処理の電界を十分にかけられず、圧電体薄膜として機能しないことになる。

【００３２】

【実施例】以下に実施例を挙げて本発明をより具体的に説明する。

【００３３】［実施例１］単結晶基板であるサファイア基板上に、ゾルゲル法で０．８μｍのＰＺＴ薄膜を形成した。ゾルゲル法に用いるＰＺＴは１８％濃度溶液を用いる。４００℃の熱処理で塗布を繰り返し所望の膜厚を得、最後に６５０℃の温度で焼成する。更に、ＰＺＴ薄膜の上にＡｌ：１５００Åを形成し、図１の様にＡｌを７０×７０μｍ角のパターンを３μｍ間隔で２つパターニングした。そして、図２の様に基板の裏面を７０×３μｍ角の開口部を逆スパッタ法によってドライエッチングした。そした、分極処理は、上部電極間に１５０℃で、３００ｋＶ／ｃｍの直流電界を１０分間印可した。こうすることで、横方向に分極されたことになり、本発明の圧電薄膜共振子１（以下、本発明共振子１と言う）を得た。

【００３４】ＰＺＴ薄膜の形成には、下記組成のＰＺＴ薄膜形成用組成物を用い、これをスピンコータにより塗布した。

<u>ＰＺＴ薄膜形成用組成物</u>（金属酸化物換算の合計濃度：２０重量％）

酢酸鉛：２３．９８５重量％

テトラブトキシジルコニウム：１１．４５５重量％

テトライソプロポキシチタン：７．８４２重量％

２－メトキシエタノール：残部

【００３５】［実施例２］実施例１において、単結晶基板にMgOを用い、裏面の開口部を化学ッチングによって形成し、本発明の圧電薄膜共振子２（以下、本発明共振子２と言う）を製作した。

【００３６】［実施例３］実施例１において、単結晶基板に$SrTiO_3$を用い、裏面の開口部を逆スパッタ法により形成し、本発明の圧電薄膜共振子３（以下、本発明共振子３と言う）を製作した。

【００３７】［実施例４］実施例１において、圧電体薄膜が１０％濃度溶液を用いたゾルゲル法で形成された０．６４μｍのＰＴ薄膜からなる本発明の圧電薄膜共振子４（以下、本発明共振子４と言う）を製作した。

【００３８】［実施例５］実施例２において、圧電体薄膜が１０％濃度溶液を用いたゾルゲル法で形成された０．６４μｍのＰＴ薄膜からなる本発明の圧電薄膜共振子５（以下、本発明共振子５と言う）を製作した。

【００３９】［実施例６］実施例３において、圧電体薄膜が１０％濃度溶液を用いたゾルゲル法で形成された０．６４μｍのＰＴ薄膜からなる本発明の圧電薄膜共振子６（以下、本発明共振子６と言うを製作した）。

【００４０】［実施例７］実施例１において、ＰＺＴ薄膜の成膜後、図３に示すごとく、振動領域以外に厚さ１μｍのSiO_2膜をスパッタにより形成し、その後、このSiO_2膜とＰＺＴ薄膜とにまたがる様に、厚さ１５００ÅのＡｌ上部電極を２つ形成したこと以外は同様にして作製した本発明の圧電薄膜共振子７（以下、本発明共振子７と言う）。この本発明共振子７について、上部電極の面積の違いによるインピーダンスを調べ、本発明共振子１と比較したところ、本発明共振子１と同じであることから、この様な構造にしても特性に変化はなく、上部電極の端子位置を確保できることが確認できた。

【００４１】上述の様に、得られた本発明共振子１～７について、圧電薄膜共振子の厚み振動の基本共振周波数を測定し、その結果を表１に示した。

【００４２】

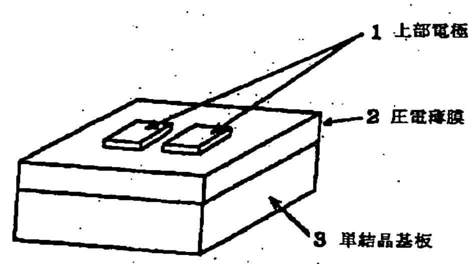
【表１】

種　　別	供振周波数
本発明共振子１	１．７５ＧＨｚ
本発明共振子２	１．７５ＧＨｚ
本発明共振子３	１．７５ＧＨｚ
本発明共振子４	１．９２ＧＨｚ
本発明共振子５	１．９２ＧＨｚ
本発明共振子６	１．９２ＧＨｚ
本発明共振子７	１．７５ＧＨｚ

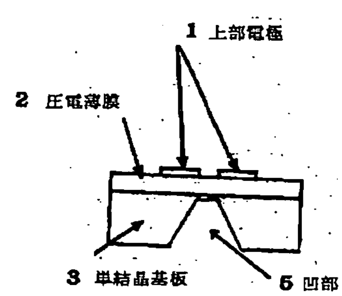
【００４３】
【発明の効果】上記の様にゾルゲル法によって、電気機械結合係数の大きいＰＺＴを用いたり、誘電率が小さく、キューリー点が約５００度と高く、厚み方向の結合係数と広がり方向の結合係数の値が大きく異なる等の特徴を持つＰＴを用いるため、構造的に図１の様な簡単な構造においても広帯域なフィルタや発振週波数の広い共振器を実現する圧電薄膜共振子を得ることが出来る。また、上部電極を所定の間隔をあけて２個設けたため、横方向のバルク波を利用する事で、音響的に不活性領域の下部電極が存在しないために大きなQ値を得ることが出来、さらに、絶縁層の上に端子電極を構成することにより、端子電極を確保でき端子電極下の共振をも抑制することが出来ると共に、圧電薄膜共振子を容易に製造することが可能となった。

【図面の簡単な説明】
【図１】　本発明の実施の形態を示す斜視図である。
【図２】　本発明の他の実施の形態を示す正面図である。
【図３】　本発明の別の実施の形態を示す斜視図である。
【図４】　本発明の異なる実施の形態を示す図であって、図４（Ａ）は正面図、図４（Ｂ）は側面図である。
【符号の説明】
１　上部電極
２　圧電薄膜
３　単結晶基板
４　絶縁膜
５　凹部

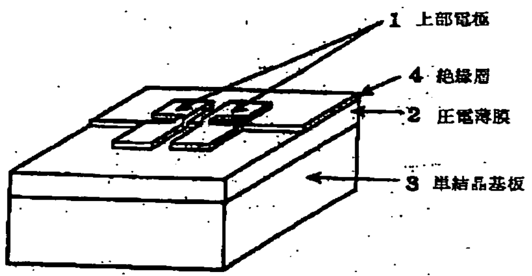
【図１】



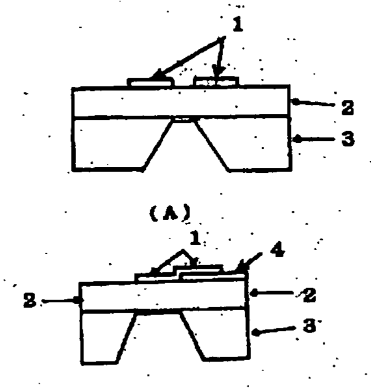
【図２】



【図3】



【図4】



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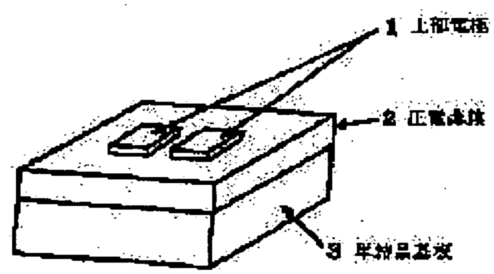
(54) PIEZOELECTRIC THIN FILM RESONATOR

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a piezoelectric thin film resonator with a wide band width and a wide oscillating frequency range when it is applied to a resonator, a filter or the like and having a large electromechanical coupling coefficient.

SOLUTION: This resonator is provided with a single crystal substrate 3, a piezoelectric thin film 2 formed on the single crystal substrate 3 and two electrodes 1 made of a conductive film formed on the piezoelectric thin film 2. In this case, the piezoelectric thin film 2 is made of e.g. lead zirconate titanate (PZT) or lead titanate (PT) thin film whose the thickness is 0.1-10 μm formed by a sol-gel method, an electric field is applied between the two electrodes 1 to apply polarization processing and to make the piezoelectric thin film. As required, an interval between the two electrodes 1 is made to 0.5-10 μm and a part of a rear side of the single crystal substrate is removed by etching.



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* NOTICES *

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1. This document has been translated by computer.So the translation may not reflect the original precisely.
2. **** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1] Single crystal substrate. The piezo-electric-crystal thin film formed on this single crystal substrate. Two electrodes which consist of conductive films formed on this piezo-electric-crystal thin film. It is the piezo-electric thin film resonator equipped with the above, and is characterized by for the above-mentioned piezo-electric-crystal thin film having consisted of the titanic-acid lead zirconate (PZT) or the lead-titanate (PT) thin film formed of the sol gel process, having applied electric field to inter-electrode [above-mentioned / two], and making titanic-acid lead zirconate (PZT) or a lead-titanate (PT) thin film a piezo-electric-crystal thin film by carrying out polarization processing.
[Claim 2] The piezo-electric thin film resonator according to claim 1 characterized by the above-mentioned titanic-acid lead zirconate (PZT) or a lead-titanate (PT) thin film being a thin film with a thickness of 0.1-10 micrometers formed by the sol gel process.
[Claim 3] The piezo-electric thin film resonator according to claim 1 to 2 to which the interval of the two above-mentioned electrodes is characterized by being 0.5-10-micrometer structure.
[Claim 4] The piezo-electric thin film resonator according to claim 1 to 3 characterized by removing a part of rear face of the above-mentioned single crystal substrate by etching.

[Translation done.]

* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention relates to the suitable piezo-electric thin film resonator for a resonator, a filter, etc. using the bulk wave of the longitudinal direction of the piezo-electric-crystal thin film which operates in a RF region.
[0002]
[Description of the Prior Art] Generally, the thickness vibration of sheet metal is used in the piezoelectric transducer used in a high frequency band. Conventionally, as a piezoelectric transducer for RFs currently offered, there is a thing of the composition of ** of a degree - ** etc.
[0003] ** The piezoelectric transducer grind piezo-electric boards, such as crystal and electrostrictive ceramics, thinly, and using the fundamental vibration.
** Higher-mode vibrator using higher harmonics, such as crystal and electrostrictive ceramics.
** Compound vibrator which forms a piezoelectric vacuum evaporationo film on a substrate, excites this piezoelectric vacuum evaporationo film, is made to carry out the higher harmonics of the substrate, and is used.
[0004] Among the above-mentioned conventional piezoelectric transducers, by the thing of the composition of **, if piezo-electric boards, such as crystal and electrostrictive ceramics, are made thin, although basic resonance frequency will become high in inverse proportion to board thickness, the more it makes board thickness thin, the more machining becomes difficult. For this reason, about 50MHz of resonance frequency is a limitation in 30-40 micrometers of board thickness now.
[0005] ** in the thing of composition, in order to use higher harmonics, an electromechanical coupling coefficient becomes small, and frequency bandwidth is small -- it elapses, and it is not practical and an electromechanical coupling coefficient is large -- low -- there is a fault used as spurious one in degree vibration Moreover, the thing of the composition of ** also has the same fault.
[0006] By the way, as a piezoelectric material for RFs for piezoelectric devices, AlN, CdS, ZnO, etc. of paraelectrics are used, for example. Though such material is thinly processed with machining, the thickness of about 40 micrometers is a limitation, and in the thing of thickness of this level, any material is [dozens of MHz of the resonance frequency of a fundamental wave] a limitation. In the piezo-electric thin film resonator for RFs using such material, in order to obtain the fundamental vibration of high resonance frequency 500MHz or more, it is necessary to set board thickness to 10 micrometers or less, for example.
[0007] On the other hand, as a method of obtaining the big piezoelectric transducer of an electromechanical coupling coefficient in a hundreds of MHz high frequency band, they are thin films, such as a spatter. The piezoelectric device indicated by this JP,60-31305,A has removed a part of substrate by etching, in order to lose the influence of a substrate and to harness the oscillation characteristic of a piezo-electric-crystal thin film.
[0008] In addition, the bulk wave of the thickness direction was excited by the electrode of the upper and lower sides of a piezo-electric-crystal film so that it might be conventionally represented with the piezo-electric thin film resonator using thickness vibration by the piezo-electric thin film resonator indicated by JP,8-148968,A. However, since a lower electrode is an inactive field in the case of the piezo-electric thin film vibrator which uses the bulk wave of the thickness direction like before, it will become hindrance and the Q value which is the important element of a resonator will become small.
[0009]
[Problem(s) to be Solved by the Invention] As mentioned above, since the electromechanical coupling coefficient is as small as about 20 - 30%, when each conventional piezoelectric material constitutes a resonator, a filter, etc., bandwidth and an oscillation frequency range are limited. In addition, although a part of substrate is removed in JP,60-31305,A in order to improve this point, when a substrate is removed in this way, there is a fault that element intensity falls.
[0010] In order to have constituted the piezo-electric large thin film material of an electromechanical coupling

coefficient like PZT conventionally, the problem was in the membrane formation process and obtaining a good membraneous piezo-electric-crystal [illegible] film had the problem referred to as dif[illegible]t. Moreover, for a dielectric constant like PT being small, the Curie point being as high as about 500 degrees, and a problem being in a membrane formation process, for constituting the piezo-electric thin film material in which the value of the coupling coefficient of the thickness direction and the coupling coefficient of the direction of a breadth has the features, such as differing greatly, and obtaining a good membraneous piezo-electric-crystal thin film, the problem referred to as difficult is ********. And in order to expose a lower electrode, a bird clapper has a process intricately, such as **********ing a piezo-electric-crystal film, or leaving a part of lower electrode and forming a piezo-electric-crystal film upwards, in order to expose a lower electrode as a terminal electrode. Moreover, since it is an inactive field acoustically, a **** intermediary and Q value will become [it] small at hindrance.

[0011] It aims at this invention solving the above-mentioned conventional trouble, an electromechanical coupling coefficient being large, the bandwidth and the oscillation frequency range at the time of applying to a resonator, a filter, etc. being a latus piezo-electricity thin film resonator, a lower electrode being unnecessary, and high Q value being obtained, therefore offering the piezo-electric thin film resonator of the request with easy manufacture.

[0012]

[Means for Solving the Problem] In the piezo-electric thin film resonator equipped with two electrodes which the piezo-electric thin film resonator of this invention becomes from a single crystal substrate, the piezo-electric-crystal film on this single crystal substrate, and the electric conduction film formed on this piezo-electric-crystal thin film The titanic-acid lead zirconate (PZT) with a thickness of 0.1-10 micrometers or the lead titanate (PT) which the above-mentioned piezo-electric-crystal film formed by the sol gel process (It is only hereafter called PZT or PT) a thin film -- having -- two easy up electrodes on the above-mentioned thin film -- having -- this -- electric field are impressed to two up electrodes, and it considers as a piezo-electric-crystal thin film by carrying out polarization processing Therefore, since a lower electrode does not exist, polarization of the polarization processing will be carried out to a longitudinal direction. Moreover, since an inactive field does not exist acoustically, high Q value is obtained.

[0013] Since the piezo-electric-crystal film is formed by PZT or PT which is a large piezoelectric material of an electromechanical coupling coefficient, the piezo-electric thin film resonator of this invention can realize a wide band filter and the large resonator of an oscillation frequency range in a RF field.

[0014] And since there is no lower electrode about a piezo-electric-crystal film by impressing electric field to this up inter-electrode one since an up electrode opens an interval and is formed two pieces, it can polarize in a longitudinal direction.

[0015] By the way, especially PZT or PT is difficult to obtain a usually good membraneous piezo-electric-crystal thin film. For example, in a spatter, such good PZT or good PT thin film cannot be formed that resonance of vibration can be checked enough.

[0016] On the other hand, if it is membrane formation of PZT or PT thin film by the sol gel process, high resonance can be shown to thickness vibration and membraneous good PZT or good membraneous PT thin film which functions effectively as a piezo-electric-crystal thin film can be formed. As for the thickness of this PZT or PT thin film, it is desirable that it is 0.1-10 micrometers.

[0017] Moreover, it is desirable still more desirable that it is 0.1-10 micrometers, and the interval between the field of a polarization treatment effect and up electrodes (an "up electrode spacing" is called hereafter.) is 0.5-5 micrometers.

[0018] this invention -- ** -- a part of single crystal substrate -- it can remove by etching, a crevice may be formed and, thereby, dispatch frequency and the property of an insertion loss can be raised

[0019] According to this invention, the thickness of PZT or PT thin film is 0.1-10 micrometers, it is 0.5-10 micrometers of up electrode spacings, and the high property piezo-electricity thin film resonator of 200MHz - 10GHz of resonance frequency bands is offered.

[0020]

[Embodiments of the Invention] Below, the form of operation of this invention is explained with reference to a drawing.

[0021] The perspective diagram in which drawing 1 shows the form of operation of this invention, the front view in which drawing 2 shows the form of other operations of this invention, the perspective diagram in which drawing 3 shows the form of another operation of this invention, and drawing 4 are drawings showing the form of the operation from which this invention differs, drawing 4 (a) is front view and drawing 4 (b) is a side elevation.

[0022] In drawing 1 -4, the same sign is given to the member which does the same function so.

[0023] Single crystal substrates, such as sapphire, and MgO, SrTiO3, can be used for the substrate used by the piezo-electric thin film resonator of this invention. If it is the single crystal substrate 1, a front face is smooth, and it can be enough come also out of a mechanical strength, and it can form good membraneous PZT or good membraneous PT thin film comparatively easily by the sol gel process with a certain thing. Moreover, as an electric conduction film which constitutes two electrodes, the film which makes aluminum, Pt, Au, etc. a principal component can be used.

[0024] On the above single crystal substrates, the piezo-electric thin film resonator of this invention forms PZT or PT

thin film, and an up electrode layer one by one, and is obtained. As an electric conduction film which constitutes two electrodes, it is a thin film with a thickness of 0.1-10 micrometers which formed membranes by the sol gel process; and PZT or PT thin film as a piezo-electric-crystal thin film can form the above-mentioned metal or an alloy film by the spatter etc., and in the usual case, the thickness is about 1000-2000A, and it gives piezoelectric by carrying out polarization processing, applying electric field to these two electrodes.

[0025] In this invention, in order to consider as RF correspondence, it is needed that it is 10 micrometers or less of thickness, and 0.1-10 micrometers of PZT(s) or the PT thin films 3 as a piezo-electric-crystal thin film is preferably determined suitably according to the purpose of use in 0.2-3 micrometers. In addition, if the thickness of PZT or PT thin film is too thin, piezoelectricity effect will not be obtained enough, and conversely, if too thick, good membraneous quality will not be obtained.

[0026] As an up electrode 4 (4A, 4B) on PZT or the PT thin film 3, patterning formation of the above-mentioned conductive metal layer can be carried out by the spatter etc.

[0027] although the mechanical strength of a piezo-electric thin film resonator is inferior a little in this invention by [with it better / to have carried out etching processing of the rear face of the single crystal substrate 1, and to form a crevice 5] forming a crevice 5 in this way as shown in drawing 2 -- low -- it can become possible to excite degree the mode more strongly, and dispatch frequency and the property of an insertion loss can be raised

[0028] As for this crevice 5, it is desirable to form in the position (position which ****(ed) the up electrode in the thickness direction on the substrate) which counters the formation position of the up electrodes 4A and 4B in 50 - 100% of depth of the thickness of the single crystal substrate 1. Under the present circumstances, a substrate is increased about several times of a piezo-electric-crystal film.

[0029] Moreover, in this invention, as shown in drawing 3 , by forming an insulator layer 4 partially on PZT or the PT thin film 3, and forming the up electrodes 4A and 4B so that the expressional side of this insulator layer 4, PZT, or the PT film 3 may be straddled, the formation position of the up electrodes 4A and 4B as a terminal electrode can be shifted, and reinforcement on structure can be aimed at. In this case, as for the thickness of this insulator layer 4, it is desirable that it is about 0.05-1 micrometer.

[0030] Next PZT or PT thin film which is a piezo-electric-crystal thin film of this invention is made like, and is formed. On a single crystal substrate, lead compound; tetrapod ethoxy JIRUKOUMU, such as lead alkoxides, such as carboxylic-acid lead, such as lead acetate, and JIISO propoxy lead A tetrapod isopropoxy zirconium, tetrapod butoxyzirconium, JIRUKO city tongues, such as zirconium alkoxides, such as a dimethoxy JIISO propoxy zirconium Titanium compounds, such as titanium alkoxides, such as dimethoxy diisopropoxytitanium, by the predetermined mole ratio to solvents, such as a 2-methoxyethanol And PZT or the constituent for PT thin film formation obtained by dissolving so that the sum total concentration of metallic-oxide conversion might become about 10 - 20 % of the weight is applied by the spin coater etc. on a single crystal substrate, and it dries at 400-600 degrees C. Repeatedly, finally it calcinates at 600-700 degrees C for 1 minute to 1 hour, and PZT or PT thin film is obtained until PZT or PT thin film of thickness of a request of this application and dryness is obtained.

[0031] Polarization processing of PZT or PT thin film can be performed by impressing DC voltage of 20-50V to two electrodes formed on this PZT or PT thin film for 1 - 60 minutes. Here, although it comes to function as a piezo-electric-crystal thin film by carrying out sufficient polarization processing, if above PZT or the membraneous quality of PT thin film is inadequate, the electric field of polarization processing cannot fully be applied and it will not function as a piezo-electric-crystal thin film.

[0032]

[Example] An example is given to below and this invention is more concretely explained to it.

[0033] On the silicon on sapphire which is a [example 1] single crystal substrate, the 0.8-micrometer PZT thin film was formed by the sol gel process. PZT used for a sol gel process uses a concentration solution 18%. An application is repeated with 400-degree C heat treatment, desired thickness is obtained, and, finally it calcinates at the temperature of 650 degrees C. Furthermore, aluminum:1500A was formed on the PZT thin film, and 2 patterning of the pattern of 70x70-micrometer angle was carried out for aluminum at intervals of 3 micrometers like drawing 1 . And dry etching of the opening of 70x3-micrometer angle was carried out for the rear face of a substrate by the reverse spatter like drawing 2 . The polarization processing which **(ed) is 150 degrees C, and carried out the seal of approval of the direct-current electric field of 300 kV/cm to up inter-electrode one for 10 minutes. By carrying out like this, it means that polarization was carried out to the longitudinal direction, and the piezo-electric thin film resonator 1 (henceforth this invention resonator 1) of this invention was obtained.

[0034] This was applied to formation of a PZT thin film by the spin coater using the constituent for PZT thin film formation of the following composition.

The constituent for PZT thin film formation (sum total concentration of metallic-oxide conversion : 20 % of the weight)

lead acetate: -- 23.985-% of the weight tetrapod butoxyzirconium: -- 11.455-% of the weight tetraisopropoxy titanium: -- 7.842-% of the weight 2-methoxyethanol: -- the remainder [0035] In the [example 2] example 1, MgO

was used for the single crystal substrate, opening on the back was formed by chemistry TCHINGU, and the piezo-electric thin film resonator 2 (henceforth this invention resonator 2) of this invention was manufactured.
[0036] In the [example 3] example 1, SrTiO3 was used for the single crystal substrate, opening on the back was formed by the reverse spatter, and the piezo-electric thin film resonator 3 (henceforth this invention resonator 3) of this invention was manufactured.
[0037] In the [example 4] example 1, the piezo-electric-crystal thin film manufactured the piezo-electric thin film resonator 4 (henceforth this invention resonator 4) of this invention which consists of a 0.64-micrometer PT thin film formed by the sol gel process using the concentration solution 10%.
[0038] In the [example 5] example 2, the piezo-electric-crystal thin film manufactured the piezo-electric thin film resonator 5 (henceforth this invention resonator 5) of this invention which consists of a 0.64-micrometer PT thin film formed by the sol gel process using the concentration solution 10%.
[0039] The piezo-electric thin film resonator 6 (this invention resonator 6 and **** were manufactured hereafter) of this invention which consists of a 0.64-micrometer PT thin film in which the piezo-electric-crystal thin film was formed by the sol gel process using the concentration solution 10% in the [example 6] example 3.
[0040] It is the piezo-electric thin film resonator 7 (henceforth this invention resonator 7) of this invention produced similarly except having formed SiO2 film with a thickness of 1 micrometer by the spatter in addition to the oscillating field, as the [example 7] example 1 was shown in drawing 3 after membrane formation of a PZT thin film, and having formed two aluminum up electrodes with a thickness of 1500A so that this SiO2 film and a PZT thin film might be straddled after that. Even if it makes it such structure since it is the same as this invention resonator 1 when the impedance by the difference in the area of an up electrode is investigated and it compares with this invention resonator 1 about this this invention resonator 7, it is changeless in a property, and it has checked that the terminal position of an up electrode was securable.
[0041] As mentioned above, about the obtained this invention resonators 1-7, the basic resonance frequency of the thickness vibration of a piezo-electric thin film resonator was measured, and the result was shown in Table 1.
[0042]
[Table 1]

種　　別	供振周波数
本発明共振子１	１．７５ＧＨｚ
本発明共振子２	１．７５ＧＨｚ
本発明共振子３	１．７５ＧＨｚ
本発明共振子４	１．９２ＧＨｚ
本発明共振子５	１．９２ＧＨｚ
本発明共振子６	１．９２ＧＨｚ
本発明共振子７	１．７５ＧＨｚ

[0043]
[Effect of the Invention] As mentioned above, by the sol gel process, since PZT with a large electromechanical coupling coefficient is used or PT with the features, like a dielectric constant is small, the Curie point is as high as about 500 degrees, and the values of the coupling coefficient of the thickness direction and the coupling coefficient of the direction of a breadth differ greatly is used, the piezo-electric thin film resonator which realizes a wide band filter and the latus resonator of the oscillation week wave number also in easy structure structurally like drawing 1 can be obtained. Since the predetermined interval was opened and two up electrodes were prepared, by moreover, the thing using a lateral bulk wave Since the lower electrode of an inactive field does not exist acoustically, while being able to secure the terminal electrode and also being able to suppress the resonance under a terminal electrode by being able to obtain big Q value and constituting a terminal electrode on an insulating layer further, it became possible to manufacture a piezo-electric thin film resonator easily.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the perspective diagram showing the gestalt of operation of this invention.
[Drawing 2] It is the front view showing the gestalt of other operations of this invention.
[Drawing 3] It is the perspective diagram showing the gestalt of another operation of this invention.
[Drawing 4] It is drawing showing the gestalt of the operation from which this invention differs, and drawing 4 (A) is front view and drawing 4 (B) is a side elevation.
[Description of Notations]
1 Up Electrode
2 Piezo-electric Thin Film
3 Single Crystal Substrate
4 Insulator Layer
5 Crevice

[Translation done.]